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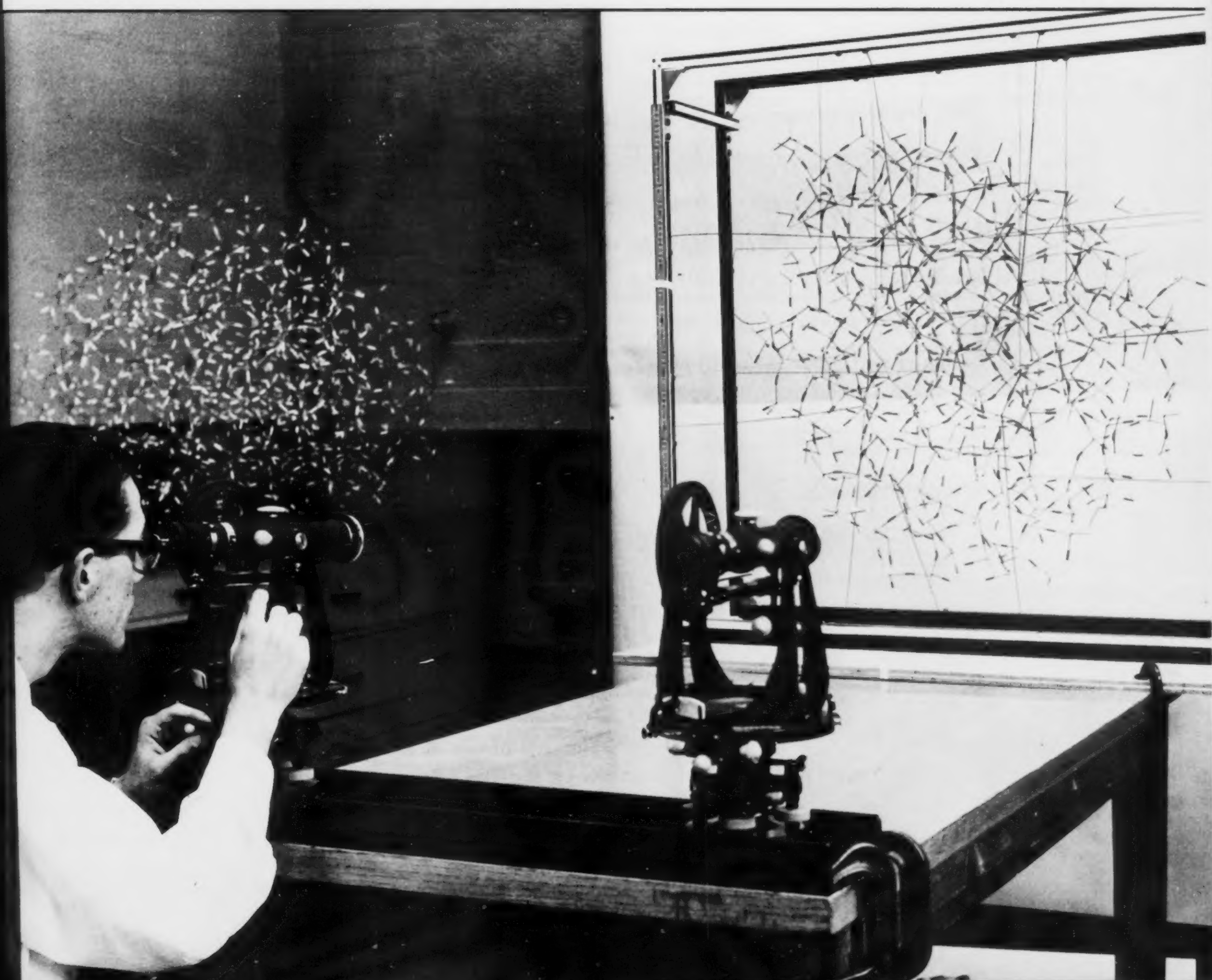

U.S. DEPARTMENT OF COMMERCE   LUTHER H. HODGES, *Secretary*

NATIONAL BUREAU OF STANDARDS   A. V. ASTIN, *Director*

NATIONAL BUREAU OF STANDARDS Technical News BULLETIN

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Contents

COVER: Paul R. Miller measures the coordinates of tetrahedral units in a random network model constructed at the NBS Institute for Materials Research. The 300-unit amorphous model was assembled according to a set of rules that represent molecular processes in a condensing fluid.

NBS develops

RANDOM NETWORK MODELS

A SYSTEMATIC procedure for constructing complex random-network models of amorphous substances [1] has been devised by Fred Ordway at the NBS Institute for Materials Research. He has found that models of large, noncrystalline structures can be assembled from tetrahedral units by following a set of rules that approximately represents a real condensation process. Numerical data can be obtained from the network models for comparison with experimental results on such substances as vitreous silica and liquid water. Further work along these lines may permit the use of an automatic computer to obtain the coordinates of much larger models without building and measuring the models at all.

Present knowledge of the structure of solids is based on the study of crystalline substances because their regular, periodic structures can be precisely determined by x-ray diffraction measurements. Many glassy and polymeric materials have no regular, periodic molecular arrangement, although the bonding between atoms is presumably very similar to that found in crystals. The structural arrangement of glasses, even the simplest ones such as vitreous silica (SiO_2), has not been determined conclusively. Several useful approximations have been developed, however. Definite structural models have been proposed and quantitatively examined, but these have been complex arrangements of high symmetry. A more realistic but less definite theory has been that of the random network.

The random network is conceived as a structure in which the relation between adjacent units is defined rather rigidly by the number and length of bonds to each unit and by the limitations on bending or rotation of bonds. The relations between more distant units vary, depending on the variations of bending and rotation within permitted limits. The desired quantitative structural data on a random network model must be statistical data; previously, these have merely been approximated by simple mathematical functions. The object of the present study is to set up a definite and realistic random-network model of sufficient size to yield good estimates of statistical functions such as density and radial distribution function.

The network models are built up from four-legged wire units devised earlier by L. W. Tilton.[2] Each of these "tetrapods" is added to the model sequentially by joining the end of a leg of one tetrapod to that of another with a short piece of flexible tubing. The ends of the four 5-cm legs of each tetrapod correspond to the vertices of a coordination tetrahedron such as the SiO_4 group in silica; their junction corresponds to the center of the tetrahedron.

A set of construction rules defines the site at which the new unit is attached, the position to which its other three legs are rotated, and the formation of any bonds to the other three legs. Each unit may be rotated freely and bent about its joint within specified limits. These rules represent, very approximately, the behavior of molecules in a condensing fluid.

If construction begins with a nucleus of one of the regular crystalline structures, growth of the regular structure continues. If the rules are followed from the start, however, the model in its early stages has noncrystalline symmetry. Such symmetry cannot be continued indefinitely as new units are added, however, and the random network eventually develops. The resulting model has no unshared vertices except those normally present at the surface, and has been built up to 300 units with no apparent limit to further additions.

The present rules can be made specific enough to be followed by an automatic computer, but probably will be modified somewhat for efficiency of computation. The computer could provide models large enough to give any required accuracy in the statistical data, and the detailed study of a variety of models may ultimately yield a new degree of refinement for the random network theory.

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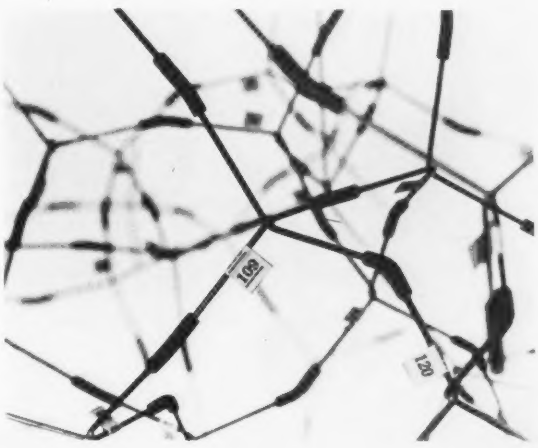
[1] A condensation model producing crystalline or amorphous tetrahedral networks, *by Fred Ordway, Science* **143**, *800–801 (Feb. 21, 1964)*.

[2] Noncrystal ionic model for silica glass, *by L. W. Tilton, J. Res. NBS* **59**, *No. 2, 139–154 (Aug. 1957)*.

Three hundred tetrahedral units like the one shown here were used in constructing a random network model. Each unit is sequentially numbered as it is added. The model is constructed according to rules that govern the placement of the unit, the rotation of its legs, and the formation of any bonds to its legs.



Filters Facilitate Color Measurements

TO FACILITATE routine color measurements, the NBS Institute for Basic Standards recently developed tristimulus filters for use as integral parts of a thermoelectric colorimeter. Consisting of different colored glasses combined with various chemical solutions, the filters approximate the color-matching functions of the average normal eye as defined by the CIE standard observer.[1] Hence, the colorimeter may be used without reference to human observers for rapid and sensitive color determinations.[2]

Visual colorimeters are often employed for color analysis and color control in manufacturing processes. In these instruments, a specimen of unknown color is compared with known color standards until a color match is obtained. However, since color vision varies in individual observers, it is usually necessary to average the measurements made by a number of observers to obtain values within the tolerances required by color specifications. Since this process is time-consuming, the Institute has been seeking a more rapid, yet accurate, method.

The use of a thermoelectric colorimeter in which tristimulus filters are combined with a thermopile is a possible method. The filters would have to modify the response of the thermopile in such a way that the $\bar{x}$, $\bar{y}$, and $\bar{z}$ functions of the CIE standard observer (see footnote 1) could be obtained on the instrument's recorder. Then the ratio of two irradiance measurements—the first, with a single tristimulus filter intro-

TABLE 1. ***Compositions of solutions***

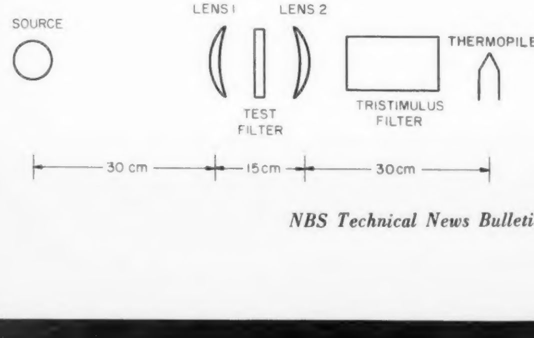
a. Solution I for $\bar{x}$-short and $\bar{z}$ filters	
Cobalt ammonium sulfate ($CoSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$).	13. 0 g
Nickelous sulfate ($NiSO_4 \cdot 6H_2O$)	19. 5 g
Glacial acetic acid	60 ml
Distilled water to make one liter of solution	
b. Solution II for $\bar{x}$-long filter	
Copper sulfate ($CuSO_4 \cdot 5H_2O$)	11. 0 g
Ferric sulfate ($Fe_2(SO_4)_3 \cdot 9H_2O$)	11. 5 g
Glacial acetic acid	60 ml
Distilled water to make one liter of solution	
c. Solution III for $\bar{y}$-filter	
Potassium dichromate ($K_2Cr_2O_7$)	0. 140 g
Copper sulfate ($CuSO_4 \cdot 5H_2O$)	17. 0 g
Cobalt ammonium sulfate ($CuSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$).	2. 10 g
Sulfuric acid (1.835 sp gr)	10 ml
Distilled water to make one liter of solution	

TABLE 2. ***Specifications of the glasses selected for the tristimulus filters***

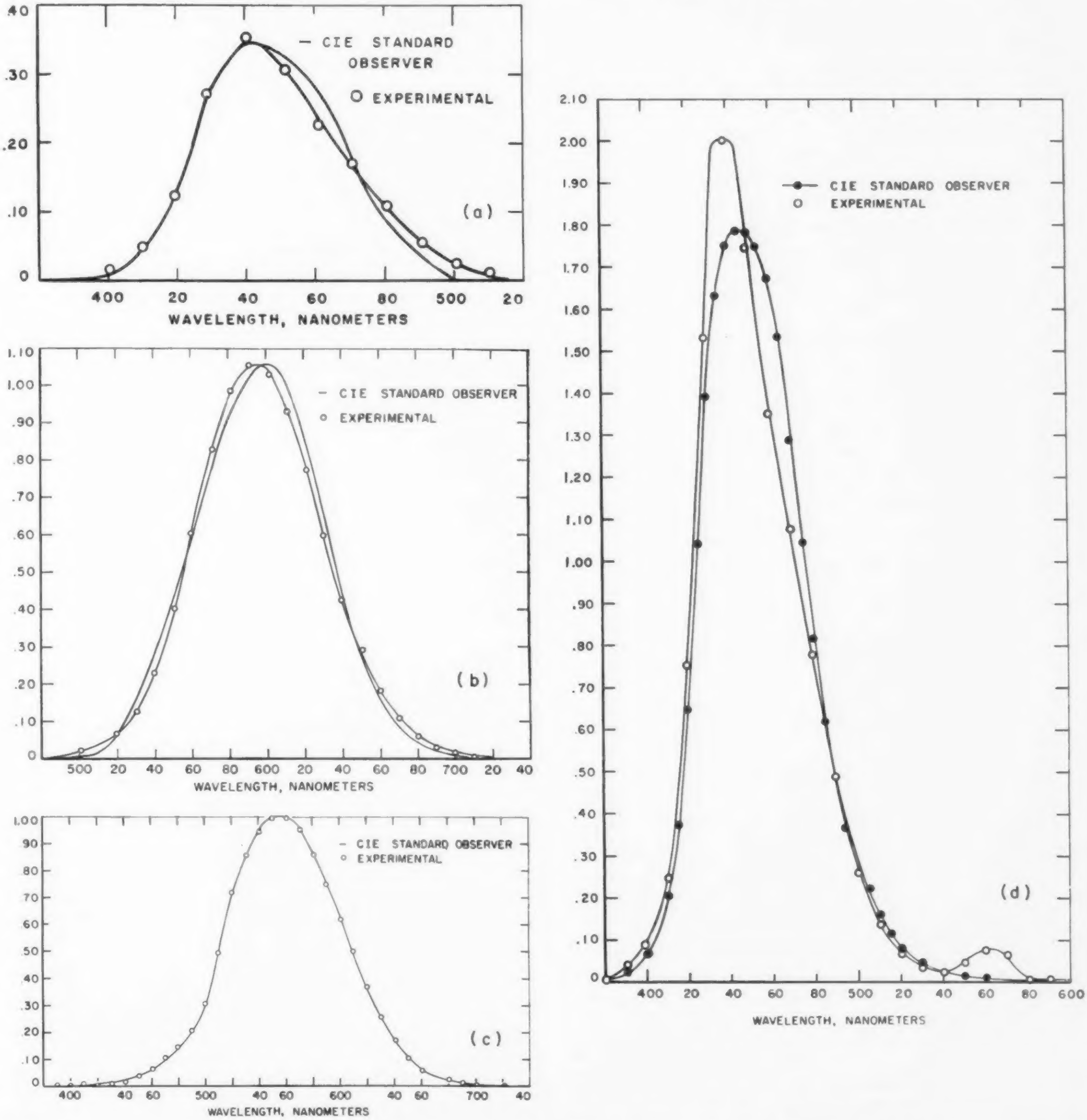
No.	Mfr.	Mfr. No.	Name	Color spec. No.	Thickness
					mm
1	Corning. .	5433	Heat resistant projector blue.	5–59	4. 4
2	Corning. .	5543	Heat resistant lantern blue.	5–60	0. 84
3	Corning. .	9788	Colorimeter blue green light.	4–97	. 615
4	Corning. .	3780	Uranium yellow.	3–80	. 67
*5	Kopp. . . .	. . . . . .	Heat absorbing.	K–48	5

*This glass may no longer be obtained from Kopp Glass Co., but it is similar to Corning filter No. 4600, color specification No. 1-69. The spectral transmittance of these heat-absorbing glasses from 560 to 780 nm is very similar to that of copper sulfate solution. Therefore, adjustment of concentration could be used to compensate for individual differences in spectral transmittance of the glass; however, other glass samples were found to be sufficiently similar that no change in solution concentration was required.

Below, left: **Mrs. Velma I. Burns inserts the chemical solution component of one of the tristimulus filters into a filter holder positioned on the photometric bar of the thermoelectric colorimeter.** ***Below, right:*** **Optical arrangement of the thermoelectric colorimeter used to check the performance of recently developed tristimulus filters. These filters are used as integral parts of the instrument to facilitate color measurements.**



Tristimulus filters have been developed to approximate the color-matching functions that define the CIE standard observer. These graphs show (*a*) the spectral transmittance of the $\bar{x}$-short filter compared to the CIE $\bar{x}_{(\lambda)}$ tristimulus values at the short-wave end of the visible spectrum; (*b*) that of the $\bar{x}$-long filter compared to the CIE $\bar{x}_{(\lambda)}$ values at the long-wave end of the visible spectrum; (*c*) that of the y filter compared to the CIE $\bar{y}_{(\lambda)}$ values; and (*d*) that of the $\bar{z}$ filter compared to the CIE $\bar{z}_{(\lambda)}$ values.



duced between a light source and the thermopile, and the second, with a test color specimen also introduced into the light beam—would be derived in turn with each of the filters. The combined values thus found would yield the color specification of the specimen. S. H. Emara,* guest worker, and R. P. Teele of the Institute's staff, therefore undertook the present work to develop filters for the irradiance measurements.

The $\bar{x}$-spectral response curve of the standard observer is bimodal; hence two filters were designed, one designated $\bar{x}$-short, representing the curve from 380 to 500 nm (in the blue spectral range), and the other, $\bar{x}$-long, representing the curve from 500 to 760

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nm (in the red spectral range). The $\bar{y}$-filter was designed to cover the green spectral range from 380 to 770 nm, and the $\bar{z}$-*filter*, the blue spectral range from 380 to 620 nm.

Spectrophotometric data obtained on the components selected for the tristimulus filters were used to compute the concentrations of the solutions and the thicknesses of the glasses required to obtain a good fit with the $\bar{x}(_\lambda)$, $\bar{y}(_\lambda)$, and $\bar{z}(_\lambda)$ values of the standard observer system. The components, together with these concentrations and thicknesses, are given in the tables on page 106.

Each filter consists of a solution (held in a 50-mm-long cell with 1-mm-thick windows) and two or more glasses. The $\bar{x}$-short filter consists of solution I and glasses 1, 2, and 5; the $\bar{x}$-long filter, of solution II and glasses 3 and 5; the $\bar{y}$-filter, of solution III and glasses 4 and 5; and the $\bar{z}$-filter, of solution I and glasses 1 and 5.

Spectral transmittance data derived for each of the four filters on a recording spectrophotometer were used to compute correction factors with which the spectral transmittances of the filters could be adjusted to obtain a close match with the responses of the standard observer. The graphs compare these adjusted transmittances for each of the four filters with the corresponding tristimulus values assigned to the CIE standard observer.

A detailed test was made of the performance of the NBS thermoelectric colorimeter, with each of the tristimulus filters introduced successively into the light beam of the source. Previously calibrated spectrophotometric standard test filters with known spectral transmittances were used for this test. An incandescent lamp operated at a color temperature of 2,854 °K was used as the source.

From the ratios of the readings obtained, values for the chromaticity coordinates of the standard test filters were computed. A comparison of the computed values with the values previously determined in the calibration of the test filters showed but minor differences, and these generally were of the order of magnitude of the uncertainties inherent in such measurements.

[1] *Established by the Commission Internationale de l'Éclairage in 1931, the CIE standard observer consists of a table of spectral values,* $\bar{x}$, $\bar{y}$, *and* $\bar{z}$, *for the amounts of the three primary colors required to match unit energy at all wavelength intervals in the visible spectrum. These values were derived statistically from the results of color measurements made by a large number of observers on red, green, and blue primaries. A graph of the values in the form of spectral tristimulus curves defines the spectral response of the average observer with normal color vision.*

[2] *For further technical details, see* Development of filters for a thermoelectric colorimeter, *by Sayeda H. Emara and Ray P. Teele, J. Res. NBS* **67C** *(Eng. and Instr.), No. 4, 319 (Oct.–Dec. 1963).*

Definitive New Reference Work

HANDBOOK OF MATHEMATICAL FUNCTIONS

The long-awaited *Handbook of Mathematical Functions* is now available after phenomenal prepublication sales of nearly 20,000 copies.

This book brings together, under one cover for the first time, text, tables, graphs, and even bibliographies. It includes the special mathematical functions normally needed by anyone who uses tables in his work, and will serve engineers, teachers, students, and scientists—including physicists, chemists, mathematicians, biologists, biochemists, and medical researchers.

The *Handbook* was compiled by the Bureau, with financial support from the National Science Foundation and technical guidance from a specially appointed Ad Hoc Committee of the Mathematics Division of the National Research Council. Twenty-six authors are represented—18 contributing authorities and 8 Bureau mathematicians, including Miss Irene Stegun and the late Dr Milton Abramowitz, who were also editors.

Ten years of labor on the part of the compilers thus culminate in what seems certain to become the definitive reference in its field. The *Handbook* expands the work of past authors by increasing the number of functions covered, presenting more extensive numerical tables, and thus giving larger collections of mathematical properties of the tabulated functions. The 29 chapter headings indicate an impressive range of the entire field, from Airy Functions to Riemann Zeta Functions. Rational approximation formulas, tailored to the modern electronic computer, are included for all the functions. They are helpful to any researcher who has access to a computer. To the scientist who does not, and who must do his own computations, these formulas are even more valuable.

The Handbook of Mathematical Functions—with Formulas, Graphs, and Tables. NBS Applied Mathematics Series 55; June 1964; 1060 pages; $6.50 per copy. Order from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402. (Foreign remittances should include additional one-fourth of the publication price to cover mailing costs.)

Eight methods compared for

Cement Heat-of-Hydration Tests

PORTLAND CEMENT is becoming an increasingly important building material as populations and industries expand. New uses are being made of this versatile material, and architects and engineers require increasing knowledge of its chemical and physical properties.

To meet these demands, chemists at the NBS Institute for Applied Technology have reviewed eight calculation procedures used in various specifications for determining the heat of hydration of portland cement by the heat-of-solution method. Such procedures differ in their timing and selection of available data, and in the details of their calculations. E. S. Newman and H. A. Berman, of the Institute staff, have reviewed the mathematics of these procedures in detail, applied them to replicate heat-of-solution determinations, and compared the reproducibility and accuracy of the results.[1] This study should be of help in developing improved test specifications both for rapidly dissolving and for slowly dissolving cements.

Portland cement generates heat in curing, a matter of concern in building dams or other massive structures. This "heat of hydration" can be measured in the laboratory using calorimetric techniques, but the observed temperature change must be corrected for the change caused by extraneous heat. Procedures for minimizing this error have been developed and included in various specifications, but the results from such determinations do not always agree.

France, Italy, the United Kingdom, and the United States were among the first countries to set up procedures for determining the heat of hydration of portland cement by heat-of-solution methods, that is, by finding the difference between the heats of solutions of a dry cement sample and a hydrated cement sample. Several other countries have established specifications based upon either the British or the American patterns. Others use an unrelated direct-hydration method for determining heat of hydration. Several studies have been published abroad comparing pairs of computational methods, but the work at the Institute was done to make an intercomparison of all the usual heat-of-solution procedures.

In this work, eight procedures were analyzed mathematically and their results compared, using the data of

Above: **Paul Neal positions a portland cement sample in the air-surrounded Dewar in preparation for a heat-of-hydration measurement. The duplicate samples are stirred by the mechanism on top of the cabinet. Temperatures are read on Beckmann thermometers.** *Left:* **E. S. Newman adds acid reagents to the reaction vessel of the platinum precision calorimeter. This is one of three calorimeter types used by NBS for comparing eight methods of determining the heat-of-hydration of portland cement.**

a heat-of-solution determination with heat-treated zinc oxide, the standard substance for portland cement calorimetry.[2,3]

Three calorimeters were also compared, using portland cement and calibrating with zinc oxide: (1) an air-surrounded Dewar flask with a Beckmann thermometer, (2) a Dewar submerged in a constant-temperature water bath, and (3) a submerged air-jacketed precision platinum calorimeter with a platinum resistance thermometer.

Pastes were prepared from each cement in duplicate, and heat-of-solution tests were made in duplicate on the dry cement, on 7-day hydrated pastes, and on 28-day hydrated pastes. A second series of pastes was prepared several days later and the same three series of heat-of-solution tests made. Four determinations were thus made for each cement at each age on each of the three calorimeters, or a total of 72 heat-of-solution determinations for the two cements. Each determination was calculated separately by the data-selection and mathematical calculation procedures required in each of the eight different methods.

Heat-of-hydration values for each cement were calculated from data collected from the tests. Results of these determinations were then analyzed statistically to determine the effects of the method of calculation, the round of the test, and the calorimeter type.

Results of the Bureau comparisons showed that, among the eight methods of determining the heat of solution of portland cement, the best reproducibility was obtained with (1) methods that use long rating periods and reading intervals, (2) methods that use time constants independent of final rating periods, and (3) methods that are not restricted by definite duration of solution and rating periods. The best accuracy was found in (1) methods having solution periods longer than 20 min, and (2) methods employing rigorous heat-leakage calculations. A constant-temperature room was found to be as effective in obtaining precision as a constant-temperature water bath for the Dewar flasks used in the specifications; however, an air-jacketed platinum calorimeter in a constant-temperature water bath is the most precise of the three types of apparatus investigated.

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[1] Calorimetry of portland cement. I. The effect of various procedures on the determination of heat of solution, *by H. A. Berman and E. S. Newman, ASTM Proc.* **63,** *830–851 (1963)*; Calorimetry of portland cement. II. The application of various heat-of-solution procedures to determinations of the heat of hydration, *by E. S. Newman and H. A. Berman, ASTM Proc.* **63,** *852–860 (1963)*.

[2] *Federal Test Method Standard No. 158A, Method 3101.1 "Heat of Hydration" (Revised Sept. 23, 1960). General Services Administration, Washington, D.C., 20405.*

[3] *ASTM Designation C186–55. Standard Method of Test for Heat of Hydration of Portland Cement. American Society for Testing and Materials, Philadelphia, Pa. 1958 Book of ASTM Standards, Part 4, pp. 164–170.*

Accelerated Program of Crystal Research

AN ACCELERATED research program on crystal growth and characterization has been initiated at the NBS Institute for Materials Research. Partly supported by the Defense Department's Advanced Research Projects Agency (ARPA) and coordinated by H. C. Allen of NBS, the program will itensify many longstanding Bureau projects in crystallography and will also promote a number of new investigations in this field.[1,2,3] Already promising results are being obtained in several research areas. Ultimately the program's findings should benefit a variety of fields including chemistry, metallurgy, mineralogy, solid-state physics, and electronics.

For many years the Bureau has been actively engaged in research and measurements on crystals in connection with its work on the basic properties of matter and materials. These continuing studies provide the nucleus for the accelerated crystal program, which is designed to obtain additional basic information on the nature of matter as well as information of more immediate utility in military and space applications. Of particular interest in such applications are crystals having piezoelectric or ferroelectric properties, crystal whiskers having unusual strength characteristics, crystalline materials that are especially resistant to extreme temperatures or pressures, materials that may provide radiation shielding, and crystals that are transparent to particular spectral wavelengths.

The activities at the Institute may be divided roughly into four general areas of investigation: (1) Crystal growth, (2) defect characterization, (3) crystal physical properties, and (4) crystal chemistry. Lines dividing these areas are difficult to draw, and some overlapping necessarily occurs.

The studies of crystal growth are conducted to determine methods for growing crystalline materials and to evaluate the causes and the effects of imperfections on crystal growth rate, kinetics, nucleation rate, and dissolution and etching characteristics. In this work metal crystals, nonmetallic inorganic crystals, and crystals of organic compounds are grown from the vapor phase, from the melt, from solution, and by electrodeposition.

The defect characterization studies are concerned with defect- or dislocation-sensitive properties of single crystals. In this area of research, theory and experimental evidence are correlated to explain defect and dislocation phenomena. Precise measurements are

Crystals of ammonium dihydrogen phosphate grown from solution in the NBS–ARPA crystal program are used to determine inherent imperfections caused by growing variables. Avery Horton water polishes a slice from such a crystal. Strains and dislocations introduced into the crystal by abrasive polishing methods are avoided by this technique. After polishing, the crystal will be examined by x-ray topography.

made on fundamental electrical properties of semiconductor crystals; other electrical and mechanical measurements are made on inorganic materials. X-ray diffraction techniques and electron microscopy will be employed widely in these studies to determine the nature and location of crystalline defects.

Studies of crystal physical properties in the NBS–ARPA program are essentially solid-state physics studies carried out independently of the degree of crystal perfection. They include measurement of physical constants, determination of the disposition of energy, and correlation of theory and experimental evidence at cryogenic and at high temperatures. These investigations involve many metals, metallic oxides, and other inorganic materials and include much research into the relationship between molecular particles and the unit crystal. An important recent contribution in this field has been the compilation of melting-point data for metal oxides as a first step toward using specific oxides for temperature standards.[4]

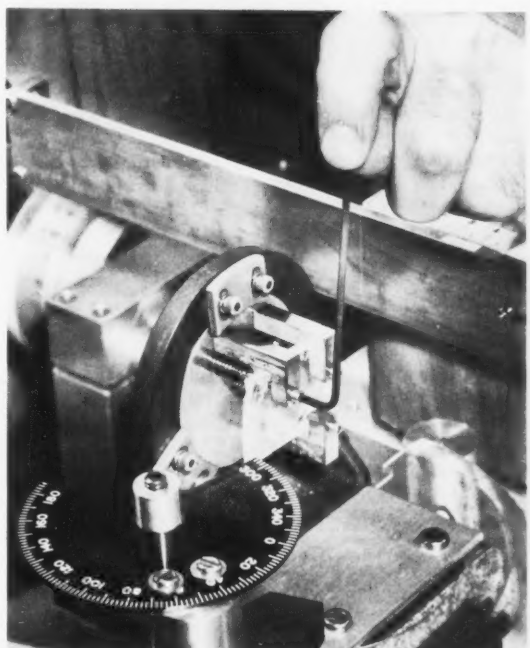
The work in crystal chemistry is concerned with individual crystal phases involving crystal structures, transformations, or chemical properties not sensitively dependent upon crystal perfection. Techniques of x-ray diffraction and spectroscopy in diverse wavelength regions are employed to observe various crystal phases. These investigations may reveal interesting properties of inorganic nonmetallic, polymeric, and glassy substances.

[1] Research on crystal growth and defect characterization at the National Bureau of Standards during the period July to December 1962, *NBS Tech. Note 174 (Mar. 15, 1963). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Price 25 cents.*

[2] Research on crystal growth and characterization at the National Bureau of Standards during the period January to June 1963, *NBS Tech. Note 197 (Sept. 23, 1963). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Price 30 cents.*

[3] Research on crystal growth and characterization at the National Bureau of Standards July to December 1963, *NBS Tech. Note 236 (Apr. 6, 1964). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Price 40 cents.*

[4] Compilation of the melting points of the metal oxides, *by Samuel J. Schneider, NBS Mono. 68 (Oct. 10, 1963). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Price 25 cents.*



Crystals of ammonium dihydrogen phosphate, grown and polished at NBS, are examined for imperfections caused by the growing technique. The polished face of the crystal is critically alined in a two-crystal x-ray spectrometer which will provide data to determine the nature of the imperfections.

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NBS PIONEER DIGITA

OVER 300 scientists, engineers, and technicians gathered at the Bureau April 23 at ceremonies marking the retirement of SEAC, the National Bureau of Standards Electronic Automatic Computer.[1]

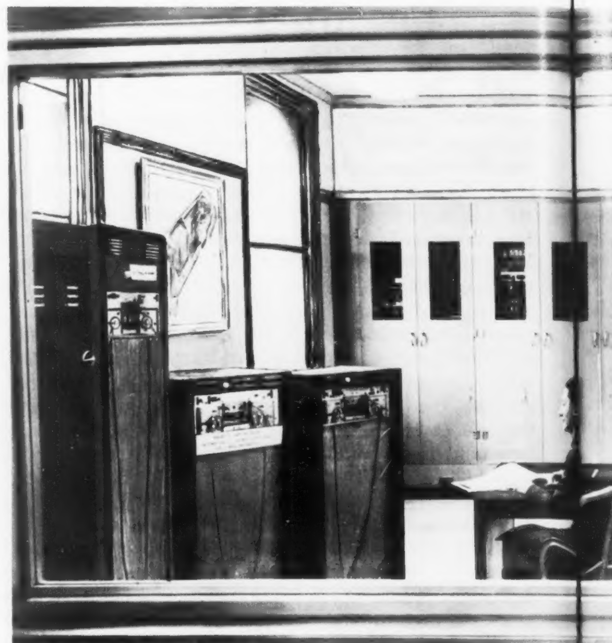
When completed in 1950, SEAC was the first internally programmed digital computer to go into operation in the United States. Developed originally to enable the Air Force to attack massive logistic problems, SEAC was also used to perform computations required in the design of the first H-bomb.

SEAC has since been used in a wide variety of computer research, including experimentation in automatic searching of chemical patents and the manipulation of pictorial data, and in such novel tasks as moving "cars" on streets existing only in the computer memory. SEAC demonstrated the feasibility of techniques important to further computer development, which contributed to successive generations of computers.

SEAC is being retired not because of an inadequate "up-time" record but rather because current problems and experiments call for the higher processing speeds and the much larger memories that are feasible today. Although assembled only 14 years ago, SEAC is exceedingly old for an electronic computer. SEAC is nonetheless still regarded with affection by those who fashioned and cared for her, as well as by numerous scientists who were first introduced to the benefits of automatic calculation through SEAC.

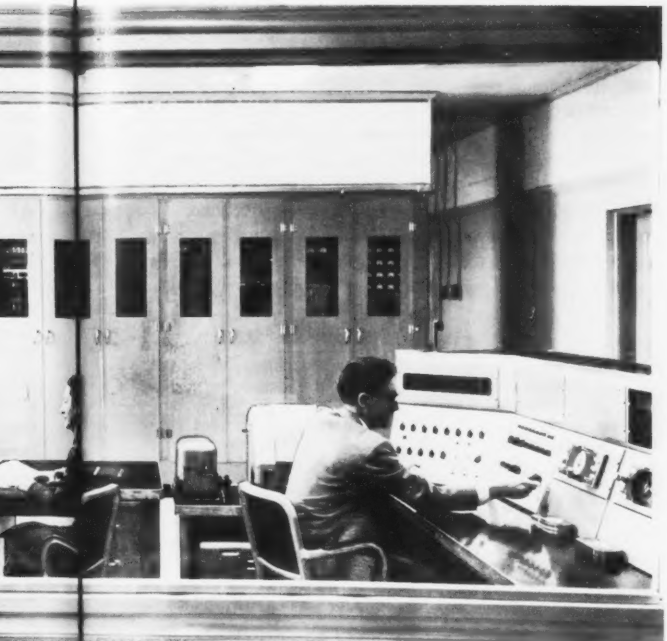
SEAC remained in service this long partly because, as an experimental installation, her capabilities were increased several times and in unusual ways during her operational life. For example, the original acoustic memory of 512 words of 45 bits with an access time of 168 μsec per word was doubled, and a Williams storage-tube memory of 512 words, which was soon increased to 1024 words with access time of 60 μsec was incorporated to provide a hybrid memory of 2048 words. The original circuitry in SEAC used a *1* MHz (1 Mc/s) clock rate which was so effective that it was adapted for use in DYSEAC, a direct descendant completed in 1954, and was further modified for a third-generation processor called the PILOT, which is replacing SEAC as an NBS research tool. Each of these systems had a progressively more dramatic extension of machine power through its novel logical organization.

The recent retirement ceremony was held almost 14 years after the ceremonies on June 20, 1950 in which the fully operational "interim" SEAC was formally dedicated at the National Bureau of Standards. Many of those who had been present at the dedication were



The retirement of SEAC, 14-year-old NBS digital computer, was announced before 300 computer technologists gathered for ceremonies at Washington on April 23. Here S. N. Alexander, now Chief of the NBS Information Technology Division, recalls the days when SEAC took form under his direction.

TA COMPUTER RETIRED



able to attend the retirement. The joint hosts at the retirement ceremonies were E. W. Cannon, Chief of the NBS Applied Mathematics Division, and Samuel N. Alexander, who 14 years ago was chief of the section that produced SEAC. He is now Chief of the NBS Information Technology Division, until recently known as the Data Processing Systems Division.

Dr. Cannon introduced John Todd, who was Chief of the NBS Computation Section when SEAC came into operation. Mr. Todd described the early experiences of the mathematicians and scientists as they adjusted themselves to the power of this new tool. Next Dr. Slutz, Mr. Alexander's assistant when SEAC was being designed and assembled, added anecdotes about those exciting days when SEAC was taking form and finally began to babble intelligently. He was followed by Mrs. Ida Rhodes, an enthusiastic pioneer in the use of SEAC, whose leavetaking of the computer was spiced with humorous incidents that occurred in the early days of SEAC's operation.

The Department of Commerce Award for Exceptional Service, which the SEAC group received from Secretary Sawyer in 1951, also had a sequel in the retirement ceremonies. I. C. Schoonover, presently Director of the NBS Institute for Materials Research, presented each of the original recipients with a special memento noting their presence at the SEAC retirement ceremonies.

James P. Nigro, Chief of the Engineering Applications Section, which has current responsibility for SEAC and PILOT, acted as master of ceremonies for the retirement program. As a finale, he presented a magnetic wire recording cartridge, a novel input unit of SEAC, to Uta Merzbach of the Smithsonian Institution's Museum of Science and Technology.

The NBS SEAC computer, the first internally programmed digital computer operated in the United States, was the guest of honor at its retirement ceremonies April 23 at the Bureau. Here SEAC is pictured when it was newly located on the NBS grounds. In the background is the computer proper, consisting of arithmetic and control units and power supply. At left is a magnetic tape auxiliary member; at right are the control console and input–output equipment.

Ten members of the NBS SEAC group which received a Department of Commerce Award for Exceptional Service in 1951 were present at the ceremonies marking the retirement of SEAC. Those present were (*from left*) R. J. Slutz, J. L. Pike, J. R. Sorrells, S. N. Alexander, Ruth H. Cahn, C. H. Page, R. D. Elbourn, A. L. Leiner, S. Greenwald, and S. L. Lubkin.

History of SEAC

In the late 1940's the Bureau, which provides technical consultative and advisory services to other Federal agencies, had been requested by the Air Force to investigate and make recomemndations for the use of computers to attack large-scale logistics problems and the associated program-planning activities. NBS recommended a basic computer sufficient for an initial instal-

lation for the Air Force problems, and contracts were let to procure this computer system. When it became apparent that delivery would be delayed, the Air Force asked NBS to design an interim system and to fabricate it. Actual construction began in early 1949, and within 20 months of accepting the task the Bureau's Electronic Computers' Section finished the machine, which was named SEAC. Machine operation was checked out with surprisingly little debugging.

To perform the task for which it was first intended, SEAC was programmed to form a rough mathematical model of Air Force operations. This model was used by the Comptroller of the Air Force to evaluate the relation of each operation to the national military objectives and to determine its logistic requirements quickly. In January 1954 the Air Force turned SEAC over to NBS. SEAC also solved problems for many other groups in the Department of Defense and the Atomic Energy Commission. The subjects ranged from the selection of contract awardees to the degradation of the neutron.

SEAC has been used in a wide range of nonmilitary applications, such as the solution of the optical skew-ray problem, in which it traced each ray through 11 optical surfaces in only 10 seconds. Designers of optical systems were for the first time enabled to thoroughly test proposed systems in minutes, whereas before they could sample only a few rays in hours. The Bureau has been using SEAC in a continuing study, sponsored by the Patent Office, to investigate means of automating patent searching, especially ways of expressing topological descriptions of chemical compounds. The machine has also been valuable in studies aimed at developing computer techniques for automatic pattern recognition.

Recent applications include operating the computer so as to simulate "drivers' decisions" and to move "cars" to successive positions on a map of city streets carried in SEAC's memory. The simulation results in the computer memory were then displayed on an oscilloscope on which moving dots represented cars moving in rush hour traffic patterns.[2] SEAC was operated in another program to determine the numbers, sizes, and form-factors of inclusions in pictorial material, making quantitative automatic metallographic and biological analyses possible.

Following the formal ceremonies those attending were invited to a demonstration of the SEAC facilities and to inspect DYSEAC and the PILOT data-processing installation, after which many continued their reminiscences at a retirement banquet.

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[1] *Another computer, SWAC (Standards Western Automatic Computer), was developed by the Bureau's Institute for Numerical Analysis at the University of California (Los Angeles). SWAC differed in that it operated in parallel fashion rather than serially. SWAC used Williams-tube memory units, obtaining an access time of 8 µsec. SWAC was transferred to the University of California in 1954, where it is still in operation.*

[2] Computer simulation of city traffic, *NBS Tech. News Bull.* **46**, 76 *(May 1962)*.

Computer Selects Best Airmail Routes

for faster delivery

COMPUTER programmers at the NBS Institute of Applied Technology have devised a program for selecting the best routes for intercity mail. Bernard M. Levin and Stephen Hedetniemi developed and tested this program, which is designed for planning mail transportation using the IBM 7090 computer.[1] The same methods can be used to select air, marine, or surface routes by both shippers and carriers in industry and government.

Selecting the best possible routes for mail transportation is a problem of very practical interest to the Post Office Department. The selection must be made on the basis of speed, desired departure or arrival time, cost, and reliability. The complexities of route selection must be dealt with on a massive basis in a short period of time twice a year, when schedules are changed with shifts to Daylight Saving Time and back. Selecting routes by computer should help ease the time pressures.

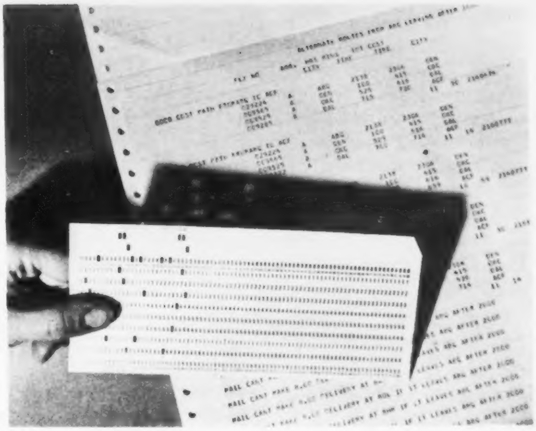
The so-called "shortest path problem," of which the selection of the quickest or cheapest route is a variant, has attracted the interest of mathematicians in the past, and more recently of computer technologists. The Post Office's problem of routing airmail served as a real problem around which the Institute could develop theoretical and practical programming techniques. In developing this method of route selection much of the actual computer programming was done by Mrs. Waveny Bryant, of the Post Office Department.

The procedure now being introduced by the Post Office is different from but related to the Institute's, and was developed by the Post Office subsequent to the Institute's program. The Post Office system is geared to its specific problem, rather than to the more general problem. It searches for necessary transfer routings by means of IBM 1401 computers, which have recently become standard equipment in that Department. Either program can be used to find the cheapest and fastest routes that can be formed from available airmail flights.

Path Selection by Computers

High-speed electronic computers are well-suited to the task of treating a large quantity of data to construct and evaluate possible routes. Furthermore, similarity of this problem to the shortest path problem, for which computer solutions have already been obtained, sug-

Punched and printed card gives airmail route selected as best by computer program. Printout underneath lists "next-best" routes and the reason each was not selected as best. Program could help the Post Office in speeding the delivery of airmail.



gested possible approaches.[2, 3] Such computer programs operate by applying algorithms, or mathematical formulas, to obtain solutions.

The algorithm used for the machine solution of the Post Office problem (see footnotes 1 and 3) was adapted for computer use by means of a program written in FORTRAN, one of man's "computer languages," for the 7090 computer. The program is capable of making route selections from among 2000 trip segments, including up to 80 transfer points.

Route Synthesis

The essential characteristic of the program is that it first determines all usable routes and then makes selections from this list of routes. It uses as input data punched cards giving for each possible link the name of the airline, the flight number, the airport and time of departure, and the airport and time of arrival. Each of these 2000 trip segments is considered as a single-link route and listed as a route for its origin-destination pair. Then each possible two-link route formed by joining contiguous single-link routes is compared with previously found routes providing the same services. Promising routes for each origin-destination pair are retained on the list in the machine memory and all others discarded. The computer goes on to form, compare, and retain selected routes by this process until the routes of $m+1$ links offer no better route than those offered by the collection of m-link and shorter routes. At this point the machine memory contains a list, for each origin-destination pair, of all routes which could possibly be named as the best route for the times being considered.

Transfers

Transfer time has an effect on the reliability of routes. More time must be allowed for interline transfers than for intraline ones; these transfer times are also related to the size of the airport. The computer was programmed to include correct transfer times, based on rules previously worked out, in synthesizing valid routes.

Generally speaking, the more time between a mail movement's arrival at an airport on a flight and its departure after transfer, the more reliable the route. However, the difference in time required for interline and intraline transfers at any airport creates the interesting possibility of a route having an interline transfer actually being less reliable than one similar, but using a parallel intraline transfer and departing at the same time, or even slightly earlier. To avoid the errors resulting from using time-on-ground as the sole indicator of transfer reliability, the computer is programmed to search, where an interline transfer is tentatively selected, for earlier outgoing flights offering the same or better reliability. An intraline transfer found in this way could be more reliable and would offer the additional advantage, in most cases, of lower cost.

Cost of Routes

Cost, as well as speed and arrival time, is a criterion for the selection of routes. The Post Office pays for air transportation on single carrier routes at rates consisting of a loading charge (based on the airport size) and a transportation charge (based on the shortest single-carrier distance). No additional charge is made for intraline transfers. Each airline participating in an interline route, however, is paid the loading charge for the airport at the start of its portion of the route, plus the transportation cost for its continuous portion. The machine program considers these charges in selecting routes.

Selection of Best Route

The many routes synthesized for each origin-destination pair are listed in the computer memory. The program instructs the computer to punch a card identifying the optimum route, and to print out a number of "next best" routes. Each next-best route is paired with an indication of the reason it was not selected as the best. The printout facilitates identification of next-best routes having outstanding characteristics and evaluation of possible tradeoffs of time with cost.

As this route-selection program is still an experimental tool, the Institute scientists have experimented with the consequences of varying selection criteria. Under one set of rules the cheapest route leaving after the required origin departure time, and arriving before the desired destination arrival time, is selected. The printout lists the next best routes in order of cost. Speed is the major criterion under another set of rules. The selections made using the various criteria are being compared to determine the best way of solving routing problems.

The route selection program has been tested on the 7090 computer, which took only 1 min to find the preferred paths from one city to 83 others for a given departure time. The program has been applied only to departures after 6 p.m. and arrivals before 8 a.m. the following morning (exclusive of Saturday night and Sunday morning), the time of primary interest to the Post Office.

Although this route-selection program as devised by the Institute could provide specific assistance to the Post Office, the techniques used also have obvious application to selection by carriers or users of air, rail, bus, truck, or composite routes. These techniques could also be used to determine the usefulness of proposed additional links. Continuing work at the Institute in this field is directed at reducing the computer capability required to make the selection, and using a "gateway" approach to permit dealing with only part of the data at once.

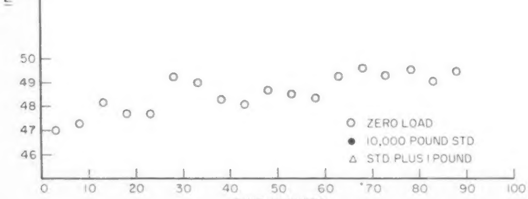
[1] Determining fastest routes using fixed schedules, *by B. M. Levin and S. Hedetniemi, Proceedings of the Spring Joint Computer Conference (1963).*

[2] On a routing problem, *by R. Bellman, Quart. Appl. Math.* **16,** *87–90 (Apr. 1958)*; On the shortest route through a network, *by G. B. Danzig, Management* Sci. **6,** *187–190 (Jan. 1960)*; *and* Solutions of the shortest-route problem—a review, *by M. Pollack and W. Wiebenson, Operations Res.* **8,** *224–230 (Mar.–Apr. 1960).*

[3] A variant on the shortest-route problem, *by G. J. Minty, Operations Res.* **6,** *882–883 (Nov.–Dec. 1958).*

Elastic Devices as Comparators for Large Weight Calibration

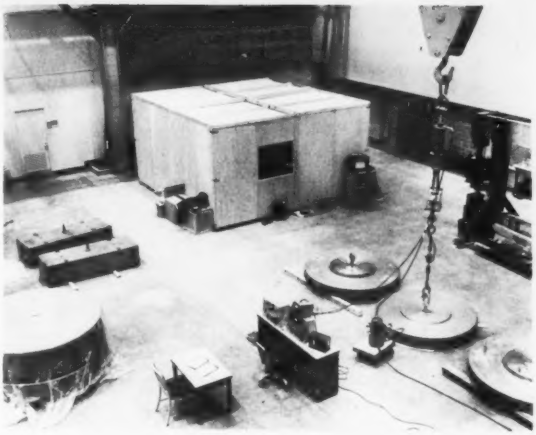
BY USING comparative rather than direct reading techniques, A. G. McNish, P. E. Pontius, and their colleagues at the NBS Institute for Basic Standards have achived precisions of 5 ppm when comparing 10,000-lb weights with a load cell. This development, which clearly indicates the increased usefulness of elastic devices when used as comparators, should permit any laboratory to use readily available equipment in the calibration of its own weights, and should save millions of dollars over the next few years through decreased down-time while weights are shipped to NBS for calibration. A remarkable aspect of the development of the technique is that just four weeks elapsed between the time of the first exploratory measurements and the first public demonstration of calibration of weights. The essence of this development is not the assembly of any particular set of equipment, but rather the use of established comparative techniques and careful statistical evaluation of the data during the development of the process.



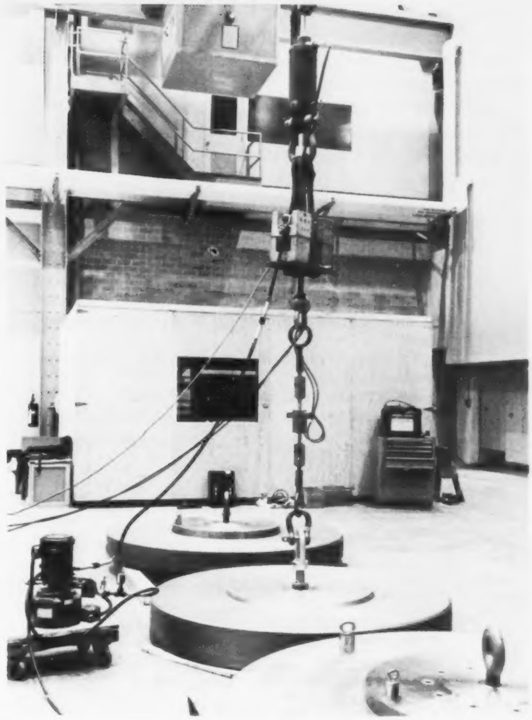
The stability of the load-cell technique at 10,000 lb is indicated by these curves. Notice that zero drift is not reflected in readings under load.

Large weights find wide application in the calibration of devices used to measure the thrust of large missile and rocket engines. Periodically the weights must be calibrated, which means the equipment is out of service while they are shipped to NBS and back. Recent increased demands for calibration have created a backlog of several months, a situation that promises to worsen while the new NBS calibration facilities at Gaithersburg, Md., are themselves being calibrated. Institute scientists decided that one way to alleviate this problem was to develop a technique whereby most installations, using off-the-shelf equipment and one NBS-calibrated weight, could perform their own calibrations. The load cell, one of several equally promising elastic devices, was investigated and proved satisfactory for such usage. It offers the advantages of precision equal to the best of platform scales, portability, rapidity of weighing, availability of equipment, and elimination of the need to have all weights calibrated by the Bureau.

Elastic devices have long been used as direct-reading instruments, and as such have been widely employed for the measurement of large weights and forces. As direct-reading devices, however, they have not provided the accuracy required for the calibration of weights.



Right: **A technique with which a load cell is used as a comparator has been used to compare large weights with high precision. The 10,000-lb. weights shown have been compared with a precision of 5 ppm. Suspended from an overhead crane (*not shown*) are a hydraulic lift, a flexure, the load cell, another flexure, and the weight. The hydraulic lift, controlled by the pump at the lower left, is used for gently raising the weights, and the flexures keep the strain in axial alinement with the cell.** *Above:* **Overall view of equipment used for comparing large weights with a load cell. The readout for the strain-gage transducer in the load cell can be seen on the desk in the foreground. The addition of 1 lb to a 10,000-lb load gives a scale deflection of 6 units.**



Almost any direct-reading device will give increased precision when used as a comparator. By taking advantage of this fact, the Bureau has been able to use the load cell to compare large weights with precisions attainable previously only with the best of platform scales. These results are probably not unique to the load cell—it is fully expected that when proving rings are used as comparators similar results will be achieved.

The equipment assembled by NBS for the comparison of 10,000-lb weights is shown in the photograph at upper right. Suspended from an overhead crane are (*top to bottom*) a hydraulic lift, a flexure, the load cell, another flexure, and a means of hooking on to the weights. The hydraulic lift is used to raise and lower the weights gently and thus avoid putting sudden stress on the cell; the flexures keep the stress in axial alinement with the cell. A variety of electronic assemblies can be used to determine the output of the strain-gage bridge in the load cell, as long as the entire system is sufficiently sensitive and successive measurements of the same quantity agree or follow a regular trend.

Initially a series of preliminary experiments was conducted to find out whether or not the load-cell technique was capable of the sensitivity sought for calibration purposes. One early result, verifying findings of others, was that a period of "exercising"—loading and unloading of the cell—is necessary to produce stable readings. Once exercised, cells left idle for more than about 15 min required additional exercise cycles. After the exercising problem was solved, it was apparent that quite reproducible results could be obtained with the load cell.

Next, a cycle was tried in which a reading was taken 3 min after loading with 10,000 lb and a zero (tare) reading was taken 3 min after unloading. This scheme gave an upward drift which, upon analysis of the data, was removed by using an asymmetric time scheme. The asymmetric cycle gave data a bit more precise than those obtained during drift. The time scheme that should be adopted probably depends on each cell, as further experience with a 300-lb device showed a symmetrical cycle to be satisfactory.

A quick search was made for major systematic errors. Tests indicated no trouble when lifting weights that were positioned slightly out of alinement with the cell. Gentle shaking of the cell and flexures did not affect the stability of readings, nor did lateral motion of the crane. Vertical tests were not tried since vertical motion was not necessary to interchange loads. A cardboard shield surrounding the cell was found necessary to minimize the thermal effects of air currents. A 30-percent overload on a 300-lb cell led to considerable instability.

Further work was then done with the addition of sensitivity weights to the 10,000-lb weight. One

pound added to the 10,000 lb gave about 6 scale units change in reading. Random amounts of up to 35 lb were added to the 10,000-lb weight and gave a linear change in response.

With this encouraging background, a weight calibration procedure that parallels the double substitution method commonly used with a balance was tried. Step by step, the cycle at 10,000 lb is as follows:

1. Exercise cell until stable readings occur.
2. Three minutes after releasing the weight (after stability is reached by exercising) take a zero reading. (While a zero reading is not used in the calculations, it is included in this scheme to monitor the stability of a particular instrument.)
3. Quickly (but gently) pick up standard weight and read after 2 min.
4. Release standard and read after 3 min.
5. Pick up unknown weight (X) and read after 2 min.
6. Release X and read zero after 3 min.
7. Pick up X and a sensitivity weight that (ideally) is a bit larger than the difference between the standard and the unknown and read after 2 min.
8. Release and read zero after 3 min.
9. Pick up standard and the same sensitivity weight and read after 2 min.
10. Release and read zero after 3 min.

Results of many intercomparisons of three 10,000-lb weights, assuming one to be exact, have given a standard deviation of 0.04 to 0.06 lb, a figure comparable to the results obtained using the best of multiple lever scales. Using another load cell, two 200-lb weights were calibrated with reference to a summation of 50-lb NBS standards, giving a standard deviation of 0.00022 lb, compared to 0.00018 lb achieved with a balance.

Further work with this technique should extend both the upper and lower limits of usefulness, and perhaps increase the precision at some loads by another order of magnitude.

Controlled Thinning of Sapphire

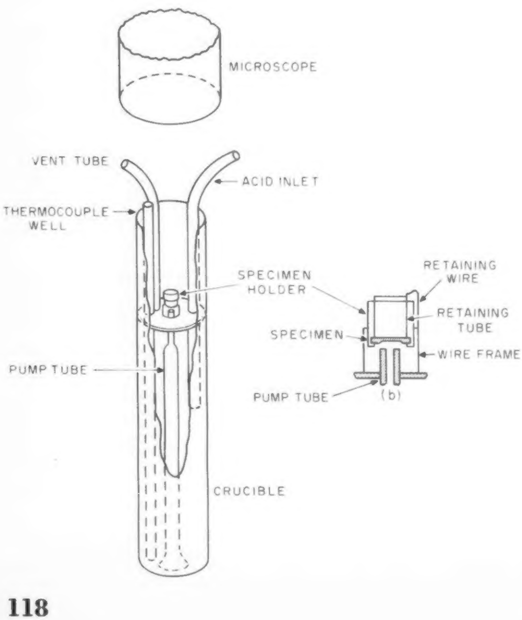
A DEVICE to control the thinning of specimens of bulk artificial sapphire (Al_2O_3) is being used at the NBS Institute for Materials Research. Devised by Nancy J. Tighe, the device[1] makes possible preparation of sapphire specimens thin enough for study by transmission electron microscopy.

Studies of nonmetallic crystals by transmission electron microscopy have lagged behind similar studies of metals because of the difficulties encountered in preparing suitable specimens. To be suitable, a portion of the specimen must be thinned to a few thousand Angstroms. For some time specimens have been thinned by mechanical cutting and polishing them chemically in a hot phosphoric acid bath. However, the rapidity of thinning in the bath has prohibited accurate control. In using the new device another step is added to the old procedure. The specimen is removed from the bath before thinning is completed and is subjected to a jet of hot phosphoric acid produced by the device.

The jet is formed by a pump tube inserted through the lid of a covered crucible containing the acid. When the acid is heated, it boils and is forced up through the pump tube to strike the specimen. Boiling is sustained at temperatures in excess of 450° C, and lost acid is replaced by adding acid through a second tube. A third tube through the crucible lid acts as a pressure vent. The device also contains a thermocouple well. The specimen is supported a short distance above the pump tube and is slowly thinned by the acid. A microscope placed over the device is used to observe and control the process.

The specimen, which is made from a single-crystal rod or boule, is thinned until a small hole is formed; it is then removed. The area bounding the hole is thin enough for study by transmission electron microscopy.

[1] *For further details, see* Jet thinning device for preparation of Al_2O_3 electron microscopic specimens, *by Nancy J. Tighe, Rev. Sci. Inst.* **35** *(Apr. 1964).*



Phosphoric acid boiling in this platinum crucible is forced upwards through the center tube and strikes the sapphire specimen. Thinning is slow because only small amounts of acid attack the specimen.

STANDARD MATERIALS

Four New Sets of Copper-Base Alloy Standards

Other Standards Re-issued

New standard samples for four groups of copper-base alloys have been issued by the NBS Institute for Materials Research.[1] Several samples, which vary in composition, are available for each of the alloys—free-cutting brass, gilding metal, commercial bronze, and aluminum brass. These standards have been prepared primarily for optical-emission and x-ray spectrochemical analysis calibrations and are in a form convenient for such use. In addition, one steel, one hydrocarbon, one rubber, and eight metal-organic standards, as well as a booklet of standard faded strips of light sensitive papers, have been re-issued.

Copper alloys are widely used wherever their inherent properties of electrical or thermal conductivity, formability, corrosion resistance, or architectural beauty may be effectively utilized. In manufacturing such alloys, the copper-zinc ratio and the addition of small amounts of other elements, such as tin, lead, silicon, and nickel, must be closely controlled. Standards of known composition are essential in calibrating the instruments used either for controlling the manufacturing processes or for consummer testing. NBS cooperates with industry and with other Government agencies in planning, developing, and providing such standards.

As with former NBS copper-alloy standards,[2] material for the new standards was melted and cast at the Naval Research Laboratory, Washington, D.C., under NBS supervision. High-purity metals were used in the standards either directly or in the preparation of master alloys. Approximately 650-lb heats were melted under a charcoal cover in a high-frequency induction furnace. The molten metal was cast on a massive water-cooled copper plate developed by NBS several years ago. The plate provides rapid unidirec-

TABLE 1. *Free-cutting brass standards*

Element [4] \ NBS No.[1]	1103	C1103 [2]	1104 C1104	C1105 [3]
	%	%	%	%
Cu	59.2_7	59.1_9	61.3_3	63.7_2
Zn	35.7	35.7	35.3	34.0
Pb	3.7_3	3.8_1	2.7_6	2.0_1
Sn	0.88	0.88	0.43	0.21
Fe	.26	.26	$.09_0$	$.04_4$
Ni	.16	.16	.071	.043
P	.003	.003	.005	.003

[1] Size and metallurgical condition: 1100 series are wrought samples 1¼ in. in diameter, ¾ in. thick. C1100 series are chill-cast samples 1¼ in. square, ¾ in. thick.

[2] Small differences in the copper and lead contents made necessary the separate analysis of the wrought and chill-cast material for this standard.

[3] The wrough material for this standard is not yet available.

[4] Bi and Ag also are present in small quantities in the standards, but these elements have not been certified.

TABLE 2. *Gilding metal standards*

NBS No. [1]	1112	1113	1114
Element [2]	C1112	C1113	C1114
	%	%	%
Cu	93.3_8	95.0_3	96.4_5
Zn	6.3_0	4.8_0	3.4_7
Sn	0.12	0.06_4	0.02_7
Ni	$.10_0$	.057	.021
Fe	$.07_0$	04_3	$.01_7$
Pb	.057	.026	.012
P	.009	.008	.009

[1] Size and metallurgical condition: 1100 series are wrought samples 1¼ in. in diameter, ¾ in. thick. C1100 series are chill-cast samples 1¼ in. sq., ¾ in. thick.

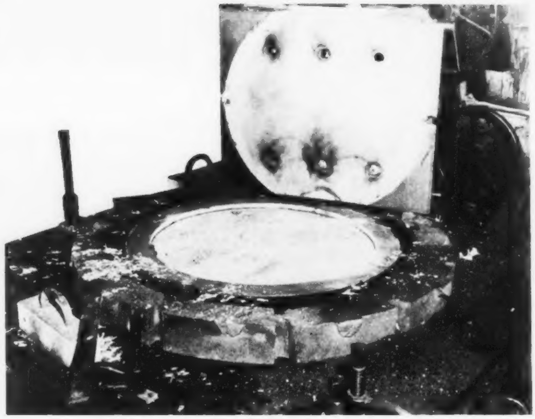
[2] Al, Mn, Ag, and Si also are present in small quantities in the standards, but these elements have not been certified.

TABLE 3. *Commercial bronze standards*

NBS No. [1]	1115	1116	1117
Element [2]	C1115	C1116	C1117
	%	%	%
Cu	87.9_6	90.3_7	93.0_1
Zn	11.7_3	9.4_4	6.8_7
Fe	0.13	0.046	0.014
Sn	.10	$.04_4$	$.02_1$
Ni	.074	.048	.020
Pb	.013	.042	.069
P	.005	.008	.002

[1] Size and metallurgical condition: 1100 series are wrought samples 1¼ in. in diameter, ¾ in. thick. C1100 series are chill-cast samples 1¼ in. sq, ¾ in. thick.

[2] Ag, Si, and Mn also are present in small quantities in the standards, but these elements have not been certified.



For most NBS Brass standards like Nos. 1104 and C1104 shown here, both chill-cast (1¼ in. sq) and wrought (1¼ in. diam) specimens are provided. Because of the unidirectional crystalline structure exhibited by chill-cast samples, they should be used only in the analysis of specimens prepared in the same manner.

Brass for NBS standard materials is cast into this 27-in.-diam, 3¼-in.-thick mold that rests on top of a massive water-cooled copper plate. The plate, developed by NBS several years ago, plays an extremely important part in providing material of high homogeneity by the rapid unidirectional solidification of the molten material.

tional solidification in each casting, which is about 27 in. in diameter and 3½ in. thick.

The aluminum brass standards presently are available only in chill-cast form, but the other three groups are available both in chill-cast and in wrought form. The material for chill-cast samples was obtained from the area of the casting nearest the chill-cast face. The material for the wrought samples was obtained after the chill-cast material was removed and about ¾ in. thickness from the slab top was discarded. Strips of the remaining material were forged, fully annealed, and finished. The samples are priced at $25 each.

Homogeneity of the material for the standards was investigated by metallographic studies and by optical emission and chemical analyses at the NBS Institute for Materials Research. Further homogeneity investigations were made by optical emission and chemical analyses by ASTM Committee E–2.[3]

TABLE 4. *Aluminum brass standards*

Element [3] \ NBS No. [1]	C1118 [2]	C1119 [2]	C1120 [2]
	%	%	%
Cu	75.0_7	77.1_2	80.1_4
Zn	21.9_1	20.5_3	18.1_0
Al	2.80	2.14	1.46
Fe	0.06_8	0.03_2	0.01_5
Pb	.024	.051	$.10_5$
P	$.12_5$	.070	.018

[1] Size and metallurgical condition: 1100 series are wrought samples of 1¼ in. in diameter ¾ in. thick. C1100 series are chill-cast samples 1¼ in. sq., ¾ in. thick.

[2] The wrought material for this standard is not yet available.

[3] Ag, As, Sb, and Si also are present in small quantitie in the standards, but these elements have not been certified.

Samples for chemical analysis of the standards were prepared from millings taken from the cross section of the finished samples of both the chill-cast and wrought material. Chemical analyses were performed by the NBS Institute for Materials Research, Washington. D.C.; Department of Mines and Technical Surveys. Mines Branch, Ottawa, Ontario, Canada; Revere Copper and Brass Inc., Rome, N.Y.; Twin City Testing and Engineering Laboratory, Inc., St. Paul, Minn.; Ledoux and Co., Teaneck, N.J.; and Research and Technical Center, Anaconda American Brass Co., Waterbury, Conn.

Re-issued Standards

Depleted supplies of standard materials are usually replaced by new materials that are similar in composition. One such replacement is NBS sample No. 19g, a 0.2-percent carbon steel standard which now contains an addition of approxiately 0.03 percent columbium. This standard for chemical composition is priced at $6 for a 150-g unit.

NBS sample No. 217b (2,2,4-trimethylpentane) is a re-issued hydrocarbon certified for density, refractive index, and calorimetric heat of combustion. The material is available in 5-, 8-, 25-, and 50-ml ampoules at prices of $12, $20, $60, and $110, respectively.

A re-issued standard for channel black rubber, NBS sample No. 375e, is priced at $14 for a 7,000-g sample. This material is used in compounding rubber to increase its abrasion resistance.

NBS standard No. 701 consists of a booklet of standard faded strips of light-sensitive papers. These papers are for calibrating carbon-arc fading lamps used in color-fastness tests of textiles. The re-issued standard, lot 2102, is priced at $60 per booklet of six faded strips.

TABLE 5. *Re-issued metal-organic standards*

Former NBS sample No. and name		Re-issued NBS sample No. and name		Metal present	Sample size	Price
				%	g	
1050	Aluminum cyclohexanebutyrate	1075	Aluminum 2-ethylhexanoate	Al 7.5	5	$10
1058	Ferric cyclohexanebutyrete	1079	Tris (1-phenyl-1, 3-butanediono) iron (III).	Fe 10.3	5	10
1059	Lead cyclohexanebutyrate	1059a	Lead cyclohexanebutyrate	Pb 36.9	5	10
1060	Lithium cyclohexanebutyrate	1060a	Lithium cyclohexanebutyrate	Li 4.1	5	10
1061	Magnesium cyclohexanebutyrate	1061a	Magnesium cyclohexanebutyrate	Mg 6.8	5	10
1068	Silver cyclohexanebutyrate	1077	Silver 2-ethylhexanoate	Ag 42.4	5	10
1072	Tris(2′-hydroxyacetophenono) chromium (III).	1078	Tris(1-phenyl-1, 3-butanediono) chromium (III).	Cr 9.58	5	10
1073	Zinc cyclohexanebutyrate	1073a	Zinc cyclohexanebutyrate	Zn 16.7	5	10

The metal-organic standards (see table 5 for re-issued samples) are stable oil-soluble substances employed in spectrographic evaluations to determine the formulation of lubricating oils.[4] These standards are also used in oil-evaluation programs aimed at determining engine wear, or predicting trouble prior to engine failure.

[1] *A complete listing of standard materials issued by NBS is contained in Standard Materials, NBS Misc. Publ. 241, which is available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (30 cents). Up-to-date supplementary insert sheets to Misc. Publ. 241 list new, re-issued, and discontinued standards, and are available from NBS without charge.*

[2] *NBS standard samples of red brass and cartridge brass are described in NBS Tech. News Bull.* **47,** *104–107 (June 1963).*

[3] *Task Group 3, Subcommitee V of ASTM Committee E–2 consists of Bridgeport Brass Co., Bridgeport, Conn.; Chase Brass and Copper Co., Waterbury, Conn.; Mueller Brass Co., Port Huron, Mich.; Olin Mathieson Chemical Corp., New Haven, Conn.; Revere Copper and Brass Co., Waterbury, Conn.; The Anaconda American Brass Co., Waterbury, Conn.; and Titan Metal Mfg. Co., Bellefonte, Pa.*

[4] *For further details see* NBS standard metal-organic materials, *NBS Tech. News Bull.* **44,** *99 (June 1960). Also, see* Analytical standards for trace elements in petroleum Products, *NBS Mono. 54 (Oct. 1, 1962), available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. 25 cents.*

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Periodicals

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